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ABSTRACT

Programs aimed at "critical thinking" should be concerned with elaborating the logic of the appropriate methodology to permit a student to evaluate the content of the instruction in terms of that methodology. An examination of four curricula, on "hominid evolution," on "marine science," on an "environmental ethic," and one urging students to "take action" on environmental problems allows identification of some methodological inadequacies which lead to learning outcomes at variance with the notion of critical thinking. Curricula such as the first two above are aimed at "knowledge;" the latter two are aimed at "action." The two types are not equivalent in their methodologies: knowledge curricula require an "enquiry" orientation and action curricula are concerned with "deliberation." However, both enquiry and deliberation have some similarities, e.g., they are both interpretative processes. Recognizing the differences and similarities, it is possible to build science curricula that allow knowledge claims to be treated in the appropriate methodological framework, enhancing critical thinking skills, and providing practice in enquiry and deliberation. (AL)

METHODOLOGY, KNOWING AND DOING IN SCIENCE EDUCATION

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METHODOLOGY, KNOWING AND DOING IN SCIENCE EDUCATION[1]

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Let me begin by remarking that I want to take some liberties with the topic of this panel "Critical Thinking and the Responsibility to Act". First, by "critical thinking" I do not mean problem-solving, nor strategies of discovery, nor do I mean skills of enquiry. Clearly, these deal with thinking, even perhaps with "critical thinking" if by "critical" we merely mean a degree of clarity, precision and efficiency in thinking. For our purposes we shall use the word "critical" in its evaluative sense i.e., to criticize or to critique. The student in our view is the potential critic and it is one of the outcomes of instruction to make him so. This view was stated long ago by Aristotle who wrote:

> Every systematic science, the humblest and the noblest alike, seem to admit of two distinct kinds of proficiency: one of which may be properly called scientific knowledge of the subject while the other is a kind of educational acquaintance with it. For an educated man should be able to form a fair off-hand judgment as to the goodness or badness of the method used by the professor in his exposition. To be educated is in fact to be able to do this.
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> It is plain then that, as in other sciences, so in that which enquires into nature, there must be certain canons, by reference to which a hearer shall be able to criticize the method of a professed exposition.[2]

A science curriculum aimed at critical thinking, is, then, concerned to elaborate the logic of scientific method in sufficient degree to permit a student, on his own and without aid from the school, to evaluate the knowledge content of science instruction in terms of the methodology with which that content was generated. This goal is not merely an abstract ideal but is attainable in ordinary classrooms. We are developing a set of curriculum materials for this purpose at OISE in the Patterns of Enquiry project.

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1. Talk presented at the National Science Teachers Association, Panel on Critical Thinking and the Responsibility to Act, New York, April 9, 1972.
2. Aristotle, 1912. *On the Parts of Animals*, Book 1, Chapter 1. The Works of Aristotle; translated by Ogle, William; edited by Smith, J.A. and W.D. Ross.

The second liberty I am taking with the title relates to my view of what it is we want students to act upon in the context of a science curriculum. I am not concerned to have students act as little researchers with the hope that they will either become researchers or support in word and tax-dollar deed the institution of science; nor am I concerned to have students act as technologists with the hope that they will become either informed voters or proponents of the good life brought to us by science and technology. I am not concerned to have students act upon personal, "persistent life problems" with the hope that science will pave the way to a smoother personal life. And, finally, I am not conerned to have students act as passionate reformers with the hope that the environment will be cleaned up and the world restored to its primitive state of beauty. For our purposes we are simply concerned to have students act intelligently upon the content of instruction with sufficient understanding on their part to free them from the twin chains of instruction, - the teacher and curriculum materials. This implies a capability for evaluating the content of instruction. Accordingly, in our view, critical thinking and the responsibility to act are merely two faces of the same instructional goal. Very briefly, then, my presentation is concerned to affirm the place of methodology as one of the content organizers of the science curriculum and to show how, under certain instructional conditions, methodology can be used to develop in students the capability of evaluating the status of the content of instruction.

SCIENCE AND ENVIRONMENTAL SCIENCE

I had originally planned to treat my topic within the confines of the ordinarily understood science curriculum, e.g., biology, chemistry, natural science. However, critical thinking and action as we see them are now emerging in a new content area, the environmental sciences, and their emergence is such that we cannot directly apply our notions from the ordinary science curriculum. Accordingly, our argument here is tortured by the fact that we must first understand the character of the subject matter of the environmental sciences and then must elaborate a conception which allows us to relate environmental sciences to science proper for purposes of curriculum. Let us illustrate our methodological concerns for these areas of the

science curriculum by examining the overriding intention of four curricula.

In "Man: A Course of Study" Bruner describes certain "truths" about tools and remarks that "all of these matters are now superbly documented in Leakey's excavations at Olduvai Gorge in East Africa".[3] However, there are legitimately different interpretations of the Olduvai Gorge documentation. First, there are certain anomolies in dating which raise a tentative note to any postulated sequence at the site. Further, respected anthropologists using different theoretical perspectives offer Olduvai Gorge interpretations different from that of Leakey. In short, the "truth" at Olduvai Gorge is not clear and unambiguous. Accordingly, the construction of a curriculum on hominid evolution, developed from a cognitive stance which insists upon characteristics such as inter-concept coherence and phenomena-concept correspondence reduces an existing diversity of knowledge claims to one. By itself, the reproduction is neutral since the selected claims may have wide-spread currency in defensible logical terms. But the learner has no basis upon which to make this judgment and, in fact, will not even realize that such judgments are made. Thus, the inadequacy of the curriculum lies not only in the simplicity of its treatment of knowledge claims but also in its ommission of the possibility of developing in learners habits of judgment about the status of knowledge claims.

(I will not identify the remaining three curricula since they are currently under development. We will refer to them as the "marine science" course, the "environmental ethic" course, and the "take action" course.)

The second course, "marine science", states its goal as follows:

> To help the students become aware of the broad and fascinating field of marine science so that they may consider it as a vocation or avocation in the future, and to create enthusiasm in the students for marine science, or science, and, in deed, for all learning.

This program moves only slightly away from the merely science content of the first and directly posses few additional critical thinking problems for use. The "marine science" curriculum developers see marine science in the same sense as any other science and we have only to ask of the curriculum "Does it provide an adequate methodological base for students to understand the status of marine science knowledge?". That is, does it provide an answer to the question "How do we know?". Leaving aside the ill-advised goal of

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3. Jerome S. Bruner, Man: A Course of Study, occasional paper No. 3, The Social Studies Curriculum Program (Cambridge, Mass: Educational Services Inc., 1965), p. 12.

turning kids into marine scientists, the problem their curriculum provides for us comes from the current milieu of public debate on the quality of our water supplies. For instance, my wife who is a biology teacher came home on Friday and dressed the family up in "Water: Let It Live" buttons. Given this milieu, one of the likely unplanned meta-learnings for kids is that they will believe that reasonable people know that the solution to our water supply problem is through marine science. As we shall show later, and as I am sure most of you believe already, this is more than patent nonsense since it violates the methodology of policy making and rules out the possibility of critical thinking on the part of the student.

The second course, which we have labeled our "environmental ethic" course, states its goal as follows:

> We recognize the immediate need for a multi-faceted program of public education designed to promote the development of a citizenry well grounded in the working knowledge of their outdoor environment and committed to the cause of protecting and preserving those natural elements that constitute the components of that environment.

This program goes beyond the second by adding a goal which might be called "adherence to the environmental ethic". The danger in this goal is that it might be achieved and that students everywhere would, to again quote the authors "be committed to the cause of protecting and preserving" whatever the circumstances.

Now, commitment is a tricky property of our mental life. When it amounts, as it does in this program, to an unreasoned holding of a moral ideal, the commitment is usually identified by such characteristics as a sense of being right; an impatience with alternative ideals; and a zealousness to search our environmental wrongs in light of the ideal. Students who are committed to ideals in this way have several possible fates in store for them. They may find themselves part of popular opinion and gain support, perhaps even recognition, for their work. More likely, they will find themselves in a deliberative milieu of competing moral ideals. By failing to understand the sense in which a moral ideal is defeasible, that is, subject to modification in its application in specific instances, and by failing to recognize what is involved in competing moral ideals, students may become frustrated and uncertain in their lack of success in implementing their stubbornly held views. Still another possible

fate derives from the recognition that moral ideals in ordinary day-to-day deliberation are modified by circumstances. This misunderstanding of the role of theory and practice in public decision making may lead to a distrust of theoretical ideals generally, and to a disinclination to search for "best" solutions.

Our fourth curriculum, which we have called the "take action" curriculum states its goal as follows:

> The theme of the course was "the environment we want". The students were all asked to contribute to this definition. Each then chose a problem area that seemed to be preventing our reaching this goal. The students were encouraged to appear before community groups to discuss their concern and the results of their investigation and to express their desires for corrective or new actions.

This program goes further than the previous one and encourages students to "get into the act" and to attempt to influence policy. Whereas the previous program stressed theoretical, moral principles at the expense of specific circumstances, this program reverses the emphasis and focuses on circumstance at the expense of principle. The limitations this places on the students capacity to think critically is equally serious, but of a different order, than the limitations placed upon students by the previous program. Here, the student is without intellectual guidance in his thinking. This characteristic leads to a cynisicm about what is best, and an opportunism in the rhetoric of support for positions. Clipsham points out that this sort of curricular situation emphasizes "desires" and leads to a student belief that the expression of desires alone, without the deliberate weighing of reasonable alternatives, produces desired practical outcomes.[4] Thus, students fail to understand the role of knowledge and reason in the process of deliberation through which policy for action is formulated.

A RE-EXAMINATION OF THE FOUR CURRICULA

So far in this presentation we have identified critical thinking as our instructional aim and we have said that this aim is achieved through a methodological understanding of the basis of the content of instruction. This position statement was followed by an account of four curricula in which we identified methodological inadequacies and errors and for which we described learning outcomes at variance with our notion of critical thinking.

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4. John Clipsham, "Organizing an Enquiry Curriculum for the Study of Issues at the Science-Society Interface." Dissertation in Progress, Department of Curriculum, The Ontario Institute for Studies in Education.

These four curricular cases are especially useful to us since we may now return to them to develop a methodological framework of use to curriculum in the development of critical thinking. In view of the time remaining to me I shall merely sketch out some of the aspects of the framework without giving the arguments upon which the framework is based.

1. Differences between curricula aimed at understanding science and those aimed at using science: Curricula one and two ("hominid evolution" and "marine science") differ from curricula three and four ("environmental ethics" and "take action") in that the first two are aimed at knowledge and understanding and the later two are aimed at action. The difference between knowledge and action has long characterized the differences between fields of study which are primarily theoretical, e.g., biology, from those that are primarily practical, e.g., the formation of policy for environmental control. We are not unaware that this distinction has been challenged on philosophical grounds, for instance by pragmatists such as Dewey. It is our belief, however, that, for now, the distinction will serve curriculum well.

2. Associated methodological differences: We now come to one of the key points, given our methodological perspective, namely, that the differences in aim i.e., knowing and action, are associated with differences in subject matter and methodology. In general, subject matter in the sciences is relatively invariable compared to the variability of the subject matter of policy formation. There are, of course, differences in the sciences themselves; with the subject matter of the biological sciences being considerably more variable than the subject matter of the physical sciences. But the variability here cannot compare with the circumstancial character of the subject matter associated with planning for desired environments.

   Methodologically, this variability leads to greater variability in the methodological "canons" upon which policy choices are warranted when compared with the methodological canons upon which scientific knowledge claims are warranted. The methodologies may be broadly characterized by the terms "enquiry" for science and "deliberation" for policy formation.

3. Methodological similarities: Our position so far would vitually rule out curricula 3 and 4 i.e., policy oriented courses, in a science curriculum. But we believe that the concerns of these curricula, particularly from the critical thinking side, are sufficiently important to develop a rational for their inclusion. Clipsham is currently developing a set of terms which will allow a curriculum worker to talk about both kinds of aims and their corresponding curricula. In addition, we can identify methodological similarities which provide a point of contact. First, both enquiry and deliberation are initiated by the imposition of a conception of how the subject matter should be treated. Using a concept of principles of enquiry Schwab has set forth a set of principles in biology and I have done it for biology and ecology. Clipsham is currently performing the function for deliberation, but here, of course, the problem is more complex since principles other than scientific ones, commonly play a role.

   The second similarity of enquiry and deliberation is that they are interpretative processes. That is, given a conception of the subject matter and its formulation in the problem, data, other valued positions and previous notions are interpreted in the light of it. Broadly speaking then, both knowledge claims, which result from enquiry, and policies for action, which result from deliberation may be understood in part, as interpretative processes.

4. Application of science to policy formation: While our four curricula do not provide us with a clear-cut case, our analysis of the second illustrates that the resolution of environmental concerns cannot be seen as a mere technological mapping of science on social problems. Technocratic notions such as this frequently crop up, of course, but we can, I think, safely dispense with them. It is here that curriculum developers run into a head-on problem. A methodological understanding of science and of policy making, of the sort sketched here, simply does not permit a harmonious bedding and coupling of science and policy concerns in the curriculum. In short, distinctions have to be made.

SUMMARY

With what, then, are we left? First, it is possible to build curricula and instructional recommendations that treat knowledge claims in their

appropriate methodological context i.e., enquiry, and which treat programs of action with respect to the environment in their appropriate methodological context i.e., deliberation. Second, it is possible to exhibit methodological similarities of enquiry and deliberation, and, thereby, to generalize a students understanding and skill in interpretating both the content of science and its use in dealing with environmental problems. Third, it is possible upon methodological grounds to sharply distinquish science from science related policy. And this, if properly done in instruction, leads to critical thinking with respect to a signifficant domain of human thought.

My last remark in this talk is that we are nor merely talking up a storm. We have curriculum materials and instructional recommendations at various stages of completion which lead to critical thinking in science and science related policy areas. Generally speaking, we are elaborating a classroom discussion format which deals with enquiry and argumentation as they occur in their respective fields. on the side of argumentation our general plan is to begin with minimum personal commitment on the part of students to an environmental problem and maximum intellectual understanding of it and then to move in the direction of increasing the degree of personal contact with the problem. Briefly, and I will describe these in more detail if anyone is interested during the question period, these amount to "analytic deliberation", which aims primarily to develop an understanding of arguments made and of the deliberative process generally; "retrospective deliberation" which utilizes case studies and asks students to take a position on an issue over which they have no control; and finally, "actual deliberation" about issues over which they do have control. The first two i.e., analytic deliberation and retrospective deliberation lead to increased understanding of the practical and theoretical aspects of deliberation. I might point out that we are not convinced that the schools ought to involve students in deliberation in the latter stage i.e., "actual deliberation".